

# SN74LVTH16952-EP

## 3.3-V ABT 16-BIT REGISTERED TRANSCEIVER WITH 3-STATE OUTPUTS

SCBS789–NOVEMBER 2003

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- Controlled Baseline
  - One Assembly/Test Site, One Fabrication Site
- Enhanced Diminishing Manufacturing Sources (DMS) Support
- Enhanced Product-Change Notification
- Qualification Pedigree<sup>†</sup>
- Member of the Texas Instruments Widebus™ Family
- State-of-the-Art Advanced BiCMOS Technology (ABT) Design for 3.3-V Operation and Low Static-Power Dissipation
- Supports Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V  $V_{CC}$ )
- Supports Unregulated Battery Operation Down To 2.7 V
- Typical  $V_{OLP}$  (Output Ground Bounce)  $<0.8$  V at  $V_{CC} = 3.3$  V,  $T_A = 25^\circ\text{C}$
- $I_{off}$  and Power-Up 3-State Support Hot Insertion
- Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors
- Distributed  $V_{CC}$  and GND Pins Minimize High-Speed Switching Noise
- Flow-Through Architecture Optimizes PCB Layout
- Latch-Up Performance Exceeds 500 mA Per JESD 17
- ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model ( $C = 200$  pF,  $R = 0$ )
- Thin Shrink Small-Outline (DGG) Package

DGG PACKAGE  
(TOP VIEW)

|          |    |    |          |
|----------|----|----|----------|
| 1OEAB    | 1  | 56 | 1OEBA    |
| 1CLKAB   | 2  | 55 | 1CLKBA   |
| 1CLKENAB | 3  | 54 | 1CLKENBA |
| GND      | 4  | 53 | GND      |
| 1A1      | 5  | 52 | 1B1      |
| 1A2      | 6  | 51 | 1B2      |
| $V_{CC}$ | 7  | 50 | $V_{CC}$ |
| 1A3      | 8  | 49 | 1B3      |
| 1A4      | 9  | 48 | 1B4      |
| 1A5      | 10 | 47 | 1B5      |
| GND      | 11 | 46 | GND      |
| 1A6      | 12 | 45 | 1B6      |
| 1A7      | 13 | 44 | 1B7      |
| 1A8      | 14 | 43 | 1B8      |
| 2A1      | 15 | 42 | 2B1      |
| 2A2      | 16 | 41 | 2B2      |
| 2A3      | 17 | 40 | 2B3      |
| GND      | 18 | 39 | GND      |
| 2A4      | 19 | 38 | 2B4      |
| 2A5      | 20 | 37 | 2B5      |
| 2A6      | 21 | 36 | 2B6      |
| $V_{CC}$ | 22 | 35 | $V_{CC}$ |
| 2A7      | 23 | 34 | 2B7      |
| 2A8      | 24 | 33 | 2B8      |
| GND      | 25 | 32 | GND      |
| 2CLKENAB | 26 | 31 | 2CLKENBA |
| 2CLKAB   | 27 | 30 | 2CLKBA   |
| 2OEAB    | 28 | 29 | 2OEBA    |

<sup>†</sup> Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

### description/ordering information

The SN74LVTH16952 is a 16-bit registered transceiver designed for low-voltage (3.3-V)  $V_{CC}$  operation, but with the capability to provide a TTL interface to a 5-V system environment.



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This device can be used as two 8-bit transceivers or one 16-bit transceiver. Data on the A or B bus is stored in the registers on the low-to-high transition of the clock (CLKAB or CLKBA) input, provided that the clock-enable ( $\overline{\text{CLKENAB}}$  or  $\overline{\text{CLKENBA}}$ ) input is low. Taking the output-enable ( $\overline{\text{OEAB}}$  or  $\overline{\text{OEBA}}$ ) input low accesses the data on either port.

When  $V_{CC}$  is between 0 and 1.5 V, the device is in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

## ORDERING INFORMATION

| T <sub>A</sub> | PACKAGE <sup>†</sup> |               | ORDERABLE<br>PART NUMBER | TOP-SIDE<br>MARKING |
|----------------|----------------------|---------------|--------------------------|---------------------|
| –40°C to 85°C  | TSSOP – DGG          | Tape and reel | CLVTH16952IDGGREP        | LH16952EP           |

## FUNCTION TABLE<sup>†</sup>

| INPUTS                      |            |                          |   | OUTPUT<br>B   |
|-----------------------------|------------|--------------------------|---|---------------|
| $\overline{\text{CLKENAB}}$ | CLKAB      | $\overline{\text{OEAB}}$ | A |               |
| H                           | X          | L                        | X | $B_0^\dagger$ |
| X                           | L          | L                        | X | $B_0^\dagger$ |
| L                           | $\uparrow$ | L                        | L | L             |
| L                           | $\uparrow$ | L                        | H | H             |
| X                           | X          | H                        | X | Z             |

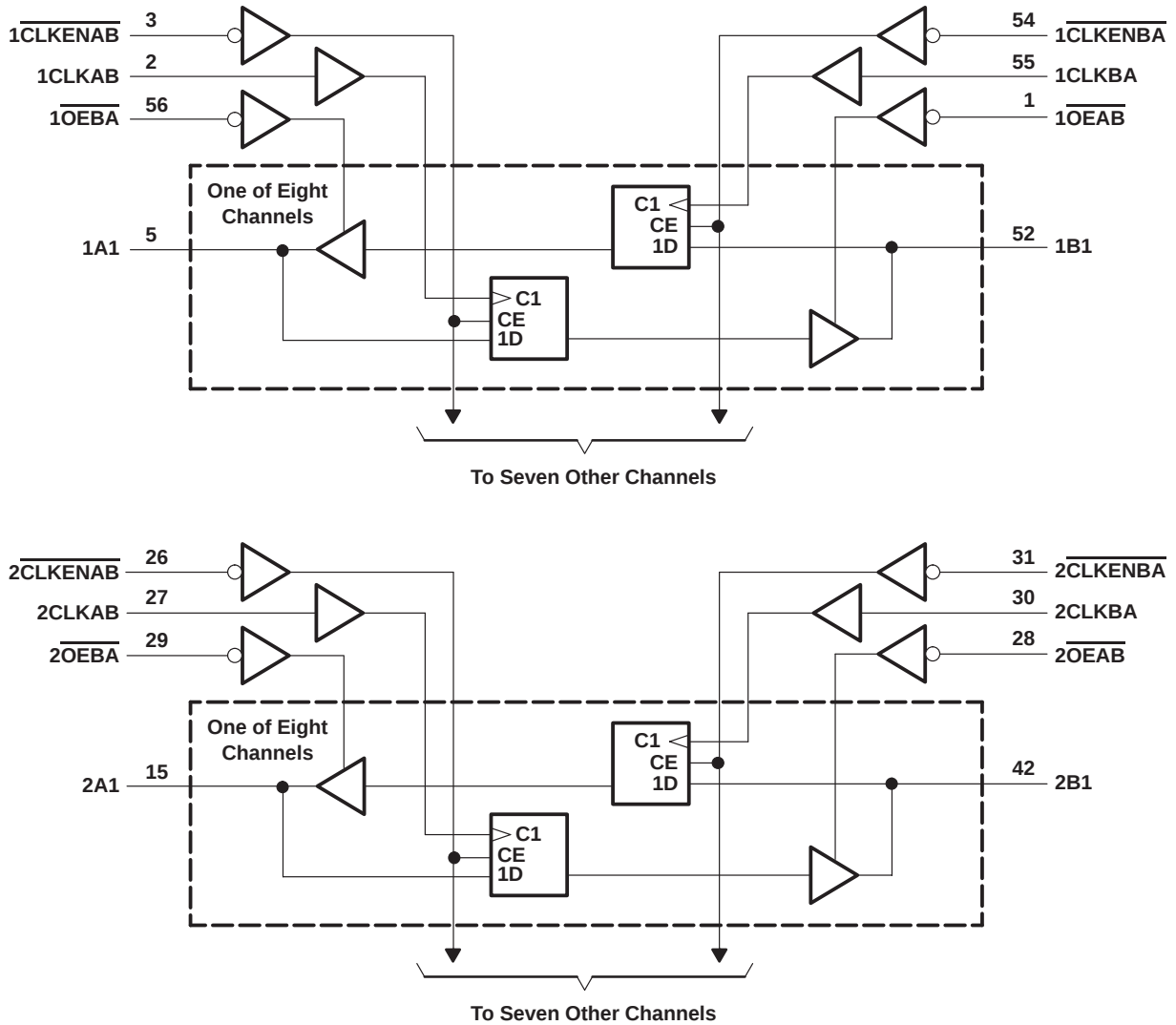
‡ Level of B before the indicated steady-state input conditions were established

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logic diagram (positive logic)



# SN74LVTH16952-EP

## 3.3-V ABT 16-BIT REGISTERED TRANSCEIVER

### WITH 3-STATE OUTPUTS

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#### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

|                                                                                                  |                            |
|--------------------------------------------------------------------------------------------------|----------------------------|
| Supply voltage range, $V_{CC}$                                                                   | −0.5 V to 4.6 V            |
| Input voltage range, $V_I$ (see Note 1)                                                          | −0.5 V to 7 V              |
| Voltage range applied to any output in the high-impedance or power-off state, $V_O$ (see Note 1) | −0.5 V to 7 V              |
| Voltage range applied to any output in the high state, $V_O$ (see Note 1)                        | −0.5 V to $V_{CC} + 0.5$ V |
| Current into any output in the low state, $I_O$                                                  | 128 mA                     |
| Current into any output in the high state, $I_O$ (see Note 2)                                    | 64 mA                      |
| Input clamp current, $I_{IK}$ ( $V_I < 0$ )                                                      | −50 mA                     |
| Output clamp current, $I_{OK}$ ( $V_O < 0$ )                                                     | −50 mA                     |
| Package thermal impedance, $\theta_{JA}$ (see Note 3)                                            | 64°C/W                     |
| Storage temperature range, $T_{stg}$                                                             | −65°C to 150°C             |

<sup>†</sup> Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.  
2. This current flows only when the output is in the high state and  $V_O > V_{CC}$ .  
3. The package thermal impedance is calculated in accordance with JESD 51.

#### recommended operating conditions (see Note 4)

|                                                        | MIN | MAX | UNIT |
|--------------------------------------------------------|-----|-----|------|
| $V_{CC}$ Supply voltage                                | 2.7 | 3.6 | V    |
| $V_{IH}$ High-level input voltage                      | 2   |     | V    |
| $V_{IL}$ Low-level input voltage                       |     | 0.8 | V    |
| $V_I$ Input voltage                                    |     | 5.5 | V    |
| $I_{OH}$ High-level output current                     |     | −32 | mA   |
| $I_{OL}$ Low-level output current                      |     | 64  | mA   |
| $\Delta t/\Delta v$ Input transition rise or fall rate |     | 10  | ns/V |
| $\Delta t/\Delta V_{CC}$ Power-up ramp rate            | 200 |     | μs/V |
| $T_A$ Operating free-air temperature                   | −40 | 85  | °C   |

NOTE 4: All unused control inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.



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**electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)**

| PARAMETER                   |                                                                    | TEST CONDITIONS                                                                                                       | MIN          | TYP† | MAX       | UNIT          |
|-----------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--------------|------|-----------|---------------|
| $V_{IK}$                    |                                                                    | $V_{CC} = 2.7\text{ V}$ ,<br>$I_I = -18\text{ mA}$                                                                    |              |      | -1.2      | V             |
| $V_{OH}$                    |                                                                    | $V_{CC} = 2.7\text{ V to }3.6\text{ V}$ ,<br>$I_{OH} = -100\text{ }\mu\text{A}$                                       | $V_{CC}-0.2$ |      |           | V             |
|                             |                                                                    | $V_{CC} = 2.7\text{ V}$ ,<br>$I_{OH} = -8\text{ mA}$                                                                  | 2.4          |      |           |               |
|                             |                                                                    | $V_{CC} = 3\text{ V}$ ,<br>$I_{OH} = -32\text{ mA}$                                                                   | 2            |      |           |               |
| $V_{OL}$                    | $V_{CC} = 2.7\text{ V}$                                            | $I_{OL} = 100\text{ }\mu\text{A}$                                                                                     |              |      | 0.2       | V             |
|                             |                                                                    | $I_{OL} = 24\text{ mA}$                                                                                               |              |      | 0.5       |               |
|                             | $V_{CC} = 3\text{ V}$                                              | $I_{OL} = 16\text{ mA}$                                                                                               |              |      | 0.4       |               |
|                             |                                                                    | $I_{OL} = 32\text{ mA}$                                                                                               |              |      | 0.5       |               |
|                             |                                                                    | $I_{OL} = 64\text{ mA}$                                                                                               |              |      | 0.55      |               |
| $I_I$                       | Control inputs                                                     | $V_{CC} = 3.6\text{ V}$ ,<br>$V_I = V_{CC}\text{ or GND}$                                                             |              |      | $\pm 1$   | $\mu\text{A}$ |
|                             |                                                                    | $V_{CC} = 0\text{ or }3.6\text{ V}$ ,<br>$V_I = 5.5\text{ V}$                                                         |              |      | 10        |               |
|                             | A or B ports‡                                                      | $V_{CC} = 3.6\text{ V}$ ,<br>$V_I = 5.5\text{ V}$                                                                     |              |      | 20        |               |
|                             |                                                                    | $V_{CC} = 3.6\text{ V}$ ,<br>$V_I = V_{CC}$                                                                           |              |      | 1         |               |
|                             |                                                                    | $V_{CC} = 3.6\text{ V}$ ,<br>$V_I = 0$                                                                                |              |      | -5        |               |
| $I_{off}$                   |                                                                    | $V_{CC} = 0$ ,<br>$V_I\text{ or }V_O = 0\text{ to }4.5\text{ V}$                                                      |              |      | $\pm 100$ | $\mu\text{A}$ |
| $I_{I(hold)}$               | A or B ports                                                       | $V_{CC} = 3\text{ V}$ ,<br>$V_I = 0.8\text{ V}$                                                                       | 75           |      |           | $\mu\text{A}$ |
|                             |                                                                    | $V_{CC} = 3\text{ V}$ ,<br>$V_I = 2\text{ V}$                                                                         | -75          |      |           |               |
|                             |                                                                    | $V_{CC} = 3.6\text{ V}^{\S}$ ,<br>$V_I = 0\text{ to }3.6\text{ V}$                                                    |              |      | $\pm 500$ |               |
| $I_{OZPU}$                  |                                                                    | $V_{CC} = 0\text{ to }1.5\text{ V}$ , $V_O = 0.5\text{ V to }3\text{ V}$ , $\overline{OE} = \text{don't care}$        |              |      | $\pm 100$ | $\mu\text{A}$ |
| $I_{OZPD}$                  |                                                                    | $V_{CC} = 1.5\text{ V to }0$ , $V_O = 0.5\text{ V to }3\text{ V}$ , $\overline{OE} = \text{don't care}$               |              |      | $\pm 100$ | $\mu\text{A}$ |
| $I_{CC}$                    | $V_{CC} = 3.6\text{ V}$ , $I_O = 0$ , $V_I = V_{CC}\text{ or GND}$ | Outputs high                                                                                                          |              |      | 0.19      | mA            |
|                             |                                                                    | Outputs low                                                                                                           |              |      | 5         |               |
|                             |                                                                    | Outputs disabled                                                                                                      |              |      | 0.19      |               |
| $\Delta I_{CC}^{\parallel}$ |                                                                    | $V_{CC} = 3\text{ V to }3.6\text{ V}$ , One input at $V_{CC} - 0.6\text{ V}$ , Other inputs at $V_{CC}\text{ or GND}$ |              |      | 0.2       | mA            |
| $C_i$                       |                                                                    | $V_I = 3\text{ V or }0$                                                                                               |              | 4    |           | pF            |
| $C_{iO}$                    |                                                                    | $V_O = 3\text{ V or }0$                                                                                               |              | 10   |           | pF            |

† All typical values are at  $V_{CC} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

‡ Unused pins at  $V_{CC}\text{ or GND}$

§ This is the bus-hold maximum dynamic current. It is the minimum overdrive current required to switch the input from one state to another.

¶ This is the increase in supply current for each input that is at the specified TTL voltage level, rather than  $V_{CC}\text{ or GND}$ .

**timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 1)**

|                    |                 |                   | $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ |     | $V_{CC} = 2.7\text{ V}$ |     | UNIT |
|--------------------|-----------------|-------------------|------------------------------------------|-----|-------------------------|-----|------|
|                    |                 |                   | MIN                                      | MAX | MIN                     | MAX |      |
| $f_{\text{clock}}$ | Clock frequency |                   |                                          | 150 |                         | 150 | MHz  |
| $t_w$              | Pulse duration  | CLK high or low   | 3.3                                      |     | 3.3                     |     | ns   |
| $t_{su}$           | Setup time      | A or B before CLK | 1.7                                      |     | 2.5                     |     | ns   |
|                    |                 | CLKEN before CLK  | 2                                        |     | 2.8                     |     |      |
| $t_h$              | Hold time       | A or B after CLK  | 0.8                                      |     | 0                       |     | ns   |
|                    |                 | CLKEN after CLK   | 0.4                                      |     | 0                       |     |      |



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WITH 3-STATE OUTPUTS

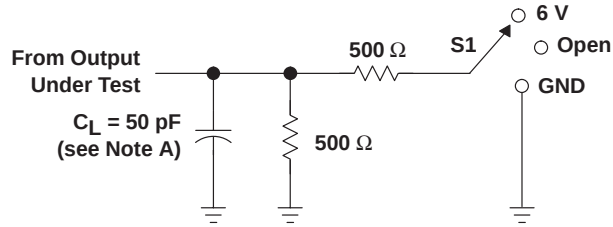
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switching characteristics over recommended operating free-air temperature range, C<sub>L</sub> = 50 pF (unless otherwise noted) (see Figure 1)

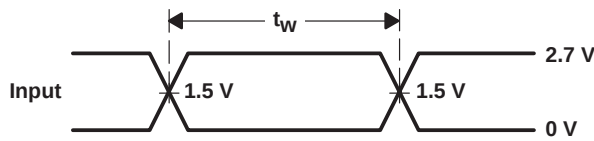
| PARAMETER        | FROM<br>(INPUT)                                      | TO<br>(OUTPUT) | V <sub>CC</sub> = 3.3 V<br>± 0.3 V |      |     | V <sub>CC</sub> = 2.7 V |     | UNIT |
|------------------|------------------------------------------------------|----------------|------------------------------------|------|-----|-------------------------|-----|------|
|                  |                                                      |                | MIN                                | TYP† | MAX | MIN                     | MAX |      |
| f <sub>max</sub> |                                                      |                | 150                                |      |     | 150                     |     | MHz  |
| t <sub>PLH</sub> | CLKBA or CLKAB                                       | A or B         | 1.3                                | 2.7  | 4   | 4.4                     |     | ns   |
| t <sub>PHL</sub> |                                                      |                | 1.3                                | 2.7  | 4   | 4.4                     |     |      |
| t <sub>PZH</sub> | $\overline{\text{OEBA}}$ or $\overline{\text{OEAB}}$ | A or B         | 1                                  | 2.3  | 4   | 4.9                     |     | ns   |
| t <sub>PZL</sub> |                                                      |                | 1                                  | 2.4  | 4   | 4.9                     |     |      |
| t <sub>PHZ</sub> | $\overline{\text{OEBA}}$ or $\overline{\text{OEAB}}$ | A or B         | 2.1                                | 3.9  | 5.7 | 6.2                     |     | ns   |
| t <sub>PLZ</sub> |                                                      |                | 2.1                                | 3.5  | 5.1 | 5.3                     |     |      |

† All typical values are at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C.

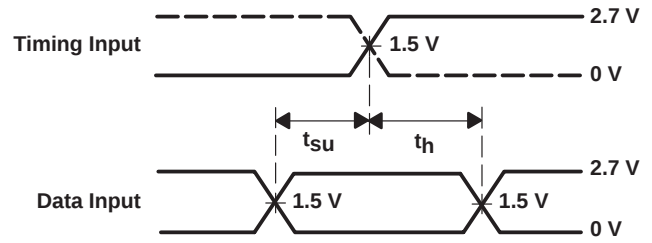
## PARAMETER MEASUREMENT INFORMATION



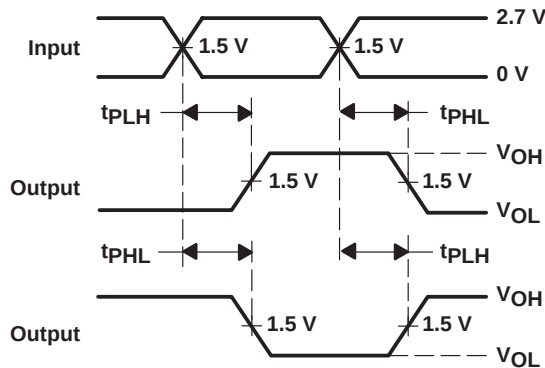
LOAD CIRCUIT



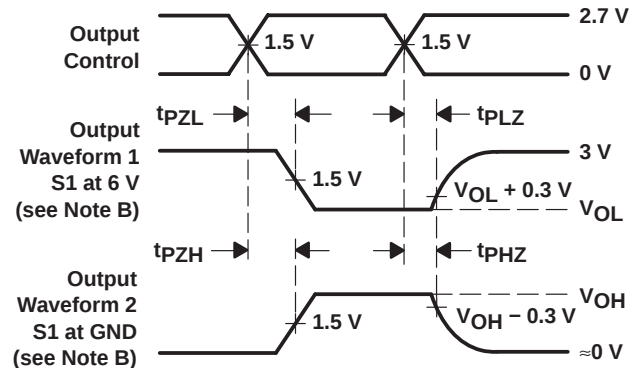
VOLTAGE WAVEFORMS  
PULSE DURATION



VOLTAGE WAVEFORMS  
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS  
PROPAGATION DELAY TIMES  
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES  
LOW- AND HIGH-LEVEL ENABLING

- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.  
 C. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ .  
 D. The outputs are measured one at a time with one transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms

**PACKAGING INFORMATION**

| Orderable Device  | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|-------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| CLVTH16952IDGGREP | ACTIVE                | TSSOP        | DGG             | 56   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| V62/04719-01XE    | ACTIVE                | TSSOP        | DGG             | 56   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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- Catalog: [SN74LVTH16952](#)
- Military: [SN54LVTH16952](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| CLVTH16952IDGGREP | TSSOP        | DGG             | 56   | 2000 | 330.0              | 24.4               | 8.6     | 15.6    | 1.8     | 12.0    | 24.0   | Q1            |

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| CLVTH16952IDGGREP | TSSOP        | DGG             | 56   | 2000 | 346.0       | 346.0      | 41.0        |

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### Products

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| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
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|                    |                                                                          |
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